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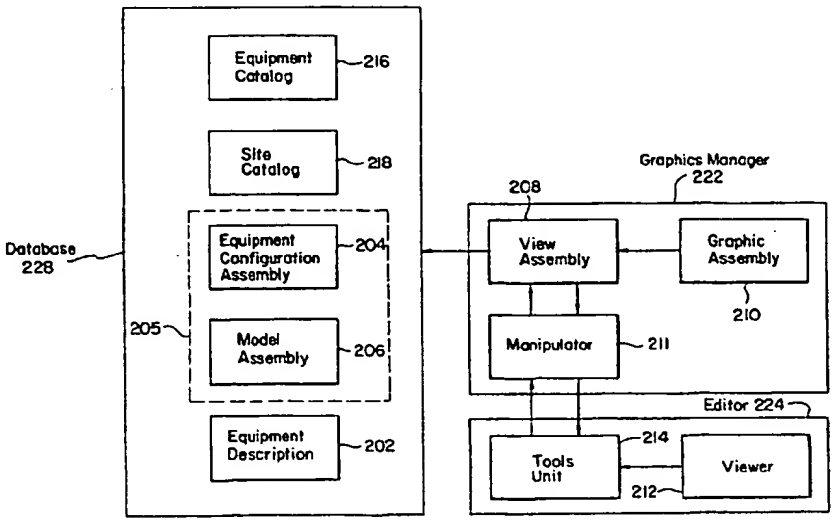

(57) Abstract

Disclosed is a method and system for implementing an intelligent graphical representation of equipment within a computer modelling system. The computer modelling system (10) has a memory, a processor (26), a visual display (12) and an input device (16 and 18). The method represents the equipment in an equipment configuration object which defines the placement of the equipment within a compatible component, and specifies connections between the equipment and the compatible component. The method also defines physical attributes of the equipment in an individual equipment description object, and associates the equipment configuration object with the equipment description object. The method further defines display characteristics of the equipment configuration object in a model object. The method also includes subscribing the model object with the equipment configuration object so that the model object is notified of changes to the subscribed equipment configuration object.

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A METHOD AND SYSTEM FOR MANIPULATING INTELLIGENT REPRESENTATIONS OF REAL EQUIPMENT WITHIN A GRAPHICAL COMPUTER SYSTEM

BACKGROUND

Field of the Present Invention

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The present invention relates to computer modeling systems, and more particularly, to systems and methods for associating information about a piece of equipment with drawings thereof.

History of Related Art

Engineering drawings are widely utilized in the design phase of complex systems. Engineers rely on drafting departments to draw their designs using Computer Aided Design (CAD) tools. The elements which are drawn by the CAD tools are graphical and have no attached meaning or behavior other than the fact that they are graphic representations of the equipment being designed. Traditional CAD systems store representations of lines, rectangles, and other graphic objects along with attributes for each graphic object (i.e., color, line thickness, etc.). CAD systems build

drawings by choosing graphic objects from a palette and arranging them on a canvas.

In the context of the mobile telecommunications industry, installation engineering is the process by which cellular capacity and coverage requirements are translated into accurate drawings, material lists, and other documents used to obtain the necessary equipment and install it in the field. Installation engineering typically begins with the selection of components. Once components are selected, engineers determine how those components should be assembled. After the various components and connections have been selected and determined, a draftsman is called upon to prepare drawings in which the components and connections are graphically represented. The drawings are typically created using a Computer Aided Design (CAD) system. CAD systems generally employ lines, rectangles and other graphical symbols to represent the various components and connections. In addition, the CAD drawings typically contain a brief description of the components and connections which form the network system. Separate documents such as material lists, databases and the like, are used to store more detailed information regarding the various components and connections incorporated into the network system. The CAD drawings and the separately maintained detailed information are manually verified to ensure consistency. The verified CAD drawings and detailed

information are eventually used in the construction and installation of the network system.

The current process of designing and implementing a telecommunication network system has several disadvantages. First, inconsistencies and errors between a CAD drawing and the separately maintained information frequently arise. Such inconsistencies may result from misunderstood communication between the engineer and the draftsman, or other similar types of human error. Second, current CAD systems fail to provide safeguards which prevent a draftsman from selecting incompatible components or making improper connections. Even a minor improper selection, such as a missing or improperly selected cable, may result in cost prohibitive delays during the construction and installation of the network system.

It would be a distinct advantage to have a system which combines drawing components with detailed information relating to those components. For example, it would be useful to "tie" a drawing component to its power rating or its serial number. Such tying would reduce inconsistencies, and it would also enable engineers and draftsmen to use the same set of drawings. It is a shortcoming and deficiency of the prior art that there has heretofore not been such a system.

Additionally, it would be a distinct advantage to have a system that uses "intelligent" components. An "intelligent" component is one that automatically

signals its proper use, e.g., connection to or installation within a compatible (as opposed to an incompatible) second component. Use of intelligent components would eliminate the making of improper connections and the selection of incompatible components. It is a shortcoming and deficiency of the prior art that there has not heretofore been such a system.

SUMMARY OF THE INVENTION

The present invention reduces the time and resources needed for the installation engineering process, and reduces errors associated with those procedures currently performed manually. Specifically, the current invention accelerates the production of engineering documentation ranging from graphical drawings, such as floor plans, to purely textual documents, such as materials lists.

The present invention is a method for providing graphic icons, each of which may represent the behavior and meaning for any piece of equipment. When designing a system, such as a large mobile telephone network, designers move icons representing particular pieces of equipment and place them within assemblies. The present invention ensures that equipment compatibility limitations are met in the proposed configuration of the assembly. Engineers are only able to place particular pieces of equipment in positions appropriate for that kind of equipment. The method also permits

multiple different views of the equipment. For example, a view can show physical configuration, logical network view, or status as a power source or power sink. These views can be displayed and manipulated, and the present invention keeps them coordinated.

The method of the present invention can be used in any Operation Support System (OSS) that concerns the configuration of equipment. The method is not limited to OSSs that deal with physical equipment, but may also be used with OSSs that deal with engineering and management aspects of logical and physical networks, such as material management, network planning, and network management systems.

The preferred embodiment of the present invention concerns the configuration of equipment in a large telecommunications network. The invention provides a representation of communications equipment that defines the configuration, containment, and connectivity of the equipment. The invention provides for the storage of this information in an object oriented database. The invention also includes one or more independent drawing models representing the information contained in a drawing of the equipment assembly, which is separated from the equipment assembly. The invention also includes a mechanism to attach, synchronize, and coordinate the equipment assembly to one or more of the independent drawing models.

Next, the invention provides an independent graphical presentation representing and defining how the actual drawing appears on the computer terminal, which is separated from the drawing model. The invention also includes a mechanism to attach, synchronize, and coordinate a plurality of graphical presentations to a drawing model. Moving a piece of equipment on the computer screen may mean different things, depending on what kind of drawing is being displayed. Therefore, a mechanism is provided to interpret user actions so that as a user manipulates an equipment icon, the system provides appropriate feedback to the user and translates the action to the appropriate operation to be performed on the underlying drawing description. The drawing model, in turn, translates the operation to one that can be performed on the underlying equipment within the equipment assembly.

The present invention reduces engineering errors in the design phase. The underlying information for each piece of equipment corrects and verifies simple errors as the equipment is placed, connected, and configured. Also, the present invention gives the engineer the feel of working with equipment rather than drawings. This provides a better user interface as it reduces the cognitive distance between the engineer's understanding of communications equipment and the computer system's internal representation and presentation of that equipment.

Thus, the present invention is an information based method for engineering of cellular telecommunications networks in a tool that supports this process. A system which employs this method is able to exchange information, to avoid duplication of data, to eliminate manual retyping of data, and to eliminate manual consistency checking, and thereby reduces the demand for resources and reduces errors.

In one aspect the present invention is a method of implementing an intelligent graphical representation of equipment within a computer modeling system. The computer modeling system having a memory, a processor, a visual display, and an input device. The method includes the step of representing the equipment in an equipment configuration object. The equipment configuration object defines the placement of the equipment within a compatible component, and specifies connections between the equipment and the compatible component. The method further includes the steps of defining the physical attributes of the equipment in an individual equipment description object, and associating the equipment configuration object with the equipment description object. The method also includes the step of defining display characteristics of the equipment configuration object in a model object. The method further includes the step of subscribing the model object with the equipment configuration object so that the model object is notified of changes to the subscribed equipment configuration object.

In another aspect, the present invention is method of updating an equipment site within an intelligent computer modeling system. The equipment site is represented by a plurality of equipment configuration objects. Each of the plurality of equipment configuration objects has a subscribing model object. The computer modeling system having a memory, a visual display, and an input device. The method includes the steps of providing a tools unit comprising a plurality of tools for interacting with the input device, and receiving a selection event from the input device which indicates a selection of one of the plurality of tools. The method further includes the step of creating a manipulator object in response to the received selection event. The method also includes the step of receiving, in the manipulator object, a plurality of manipulator events form the input device which are associated with the selected tool. The method further includes the step of interpreting the plurality of manipulator events within the manipulator object in order to provide graphical feedback to the visual display. The method also includes the steps of recording interactions between the input device and the selected tool, and transmitting a command, which corresponds to the recorded interactions, to at least one of the plurality of equipment configuration objects. The method further includes the step of updating the at least one of the equipment

configuration objects in response to the command thereby updating the site.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood and its numerous objects and advantages will become more apparent to those skilled in the art by reference to the following drawings, in conjunction with the accompanying specification, in which:

FIG. 1 (PRIOR ART) is a perspective view of an existing computer system which may be utilized to implement the preferred embodiment of the present invention;

FIG. 2 is a block diagram which illustrates the various components of the method and system of the present invention as they exist within the storage means of the computer system of FIG. 1 in the preferred embodiment of the present invention;

FIG. 3 is a class hierarchy block diagram of the equipment configuration class which is used to define equipment configuration objects within the equipment assembly of FIG. 2 in the preferred embodiment of the present invention;

FIG. 4 is a class hierarchy block diagram of the model assembly of FIG. 2 in the preferred embodiment of the present invention;

FIG. 5 is a block diagram illustrating an exemplary physical model and a logical model, each representing a same base station assembly in the preferred embodiment of the present invention;

FIG. 6 is a class hierarchy block diagram of a view class which is used to define view objects within the view assembly of FIG. 2 in the preferred embodiment of the present invention;

FIG. 7 is an illustrative example of an editor on the graphics terminal of FIG. 1 in the preferred embodiment of the present invention;

FIGs. 8A-8B together form an interaction diagram which demonstrates the steps involved in updating a model from the tool panel display of FIG. 4 in the preferred embodiment of the present invention;

FIG. 9 is a block diagram of two exemplary cellular sites existing within the database of FIG. 1, according to the teachings of the present invention;

FIG. 10 is a diagram which illustrates the hierarchy of equipment configuration objects which may exist within the equipment assembly of FIG. 9, and the relationship of the equipment configuration objects with the equipment description assembly of FIG. 9;

FIG. 11 is a diagram illustrating a plurality of assemblies having a plurality of equipment configuration, model, view and graphic objects, and an associated presentation for the (cabinet) composite equipment object of FIG. 10; and

FIG. 12 is an example illustrating various methods for interfacing with the database of FIG. 1 in the preferred embodiment of the present invention.

DETAILED DESCRIPTION

A number of companies provide information based tools, particularly in the areas of cell planning, surveillance, and maintenance management. One of the areas that has resisted the push to information based systems is engineering of the physical network. The current invention meets these needs and supports the transition from planning to operations of a network. The current invention performs the following functions:

1. Assists engineers in converting functional requirements into appropriate and correct physical requirements;

2. Produces information required for installation, operation, and materials management by informing an operator or appropriate electronic systems;

3. Maintains historical information to keep track of network evolution; and

4. Reduces the learning curve associated with the introduction of new network technologies.

As noted above, traditional CAD systems store representations of lines, rectangles, and other graphic objects along with attributes for each graphic object (i.e., color, line thickness, etc.). The present invention, in contrast, stores representations of actual equipment (i.e., cabinets, transceivers, etc.) and characteristics of each piece of equipment (e.g., product number, weight, power dissipation, etc.). In order to manipulate equipment graphically, the present

invention also maintains information about containment, connectivity, and graphic representation for the equipment.

With the present invention, equipment assemblies are built interactively, through an easy-to-use graphical layout editor. The installation engineers' focus, therefore, is shifted from producing drawings to manipulating equipment. Engineers directly manipulate and work with equipment on a conceptual level while producing high quality drawings.

All types of equipment which can be manipulated by the present invention are defined in "equipment catalogs" as individual units with their particular characteristics. Users may define frequently used assemblies of equipment. For example, a standardized, fully equipped radio base station cabinet may be engineered once and used repeatedly in subsequent projects to ensure consistent and fast engineering.

The present invention organizes thousands of pieces of equipment in a cellular network into an equipment configuration hierarchy of manageable equipment objects. An equipment object may be a site, a group of sites, or parts of a site on an arbitrary number of levels.

The equipment objects that represent a system may go through several revisions over the system's operating lifetime. A system begins as a preliminary design, passes through a few intermediate designs, and then becomes a final design that is submitted for

installation. Once installed, the system may undergo several expansions or contractions over its operating life as equipment is added or removed. The present invention maintains revisions of equipment configurations to enable tracking of the evolution of the network.

Information in the database of the present invention is also accessible to other tools. An equipment supplier can integrate the present invention with tools that support his customers' supply flow while network operators can support different tools which support the processes and procedures of the network life cycle. The present invention can interface with cell planning tools, logistic tools, commissioning tools, existing product catalogs, Maintenance Management Information Systems (MMISs), and Operations Support Systems (OSSs).

The present invention may also be used to validate engineering rules defined for each equipment type. These rules may be manufacturer constraints, industry standards, or corporate engineering guidelines. The present invention validates these rules, either when explicitly requested, or automatically following specific events. Users may also integrate the present invention with specialized external analysis tools, such as expert systems, to perform more complex validations. The rule validation capability reduces the learning curve for engineering, particularly associated with the introduction of new network

technologies. Also, design errors are detected immediately rather than at later reviews or during installation.

Referring now to FIG. 1, there is shown a perspective view of a computer system 10 which is employed in the preferred embodiment of the present invention. The preferred embodiment of the present invention is UNIX-based, and runs on hardware platforms from Sun and Hewlett-Packard. The user interface of the preferred embodiment is based on X-Windows/Motif. The design of the present invention is object oriented, and the programming language is C++. The present invention includes an object oriented database management system and an object oriented 2D/3D graphical library.

The computer system 10 comprises a computer processor 26, a graphics terminal 12, a keyboard 16 and a mouse 18. The computer processor 26 is connected to the graphics terminal 12, the keyboard 16 and the mouse 18. The computer processor 26 includes memory and storage means, and executes computer software which implements the method and system of the preferred embodiment of the present invention. In addition, the storage means of the computer processor 26 is used to store and retrieve a computer software and the database management system. The graphics terminal 12 provides a user with the ability to interact visually with the computer processor 26. The keyboard 16 and the mouse 18 are conventional user input devices. The design and

use of keyboards and mouse devices and their interface with computer systems, including graphics terminals, executive workstations, Computer Aided Design systems, and the like are well known and those skilled in the art are well aware of how to implement such input devices. Any of the known systems for interfacing the mouse 18, the keyboard 16 and the graphics terminal 12 to the computer processor 26 may be utilized in connection with the present invention. It should also be noted that alternative input means such as a graphics tablet may be utilized instead of the mouse 18.

FIG. 2 is a block diagram illustrating the various components of the method and system of the present invention as they may exist within the storage means of the computer processor 26 of FIG. 1. The method and system of the present invention comprises an equipment configuration assembly 204, an equipment description 202, a model assembly 206, an equipment catalog 216, a site catalog 218, a graphics manager 222, an editor 204, and a database 228.

The graphics manager 222 comprises a view assembly 208, a graphic assembly 210, and a manipulator 211. The graphics manager 222 is responsible for visually displaying the contents of database 228 on the graphics terminal 12 of FIG. 1.

The editor 224 comprises a viewer 212 and a tools unit 214. The tools unit 214 comprises a plurality of individual tools each of which provide editing

capabilities. The editor is used for updating the contents of database 228. The updating is accomplished by the viewer 212 and the tools unit 214 interacting with objects within the view assembly 208 through manipulator 211.

Database 228 is employed for organizing and maintaining information related to the equipment catalog 216, equipment description 202, equipment configuration assembly 204, model assembly 206 and site catalog 218. Database 228 may be, for example, any object oriented database such as Object Store, produced by Object Design Inc.

A user may add or modify a particular equipment description by accessing the equipment catalog 216 via editor 224. The site catalog 218 is used for maintaining a catalog of sites. A site is comprised of an equipment configuration assembly and a model assembly. A user may add or modify a particular site by accessing the site catalog 218 via editor 224. For example, a site 205 may be represented by the equipment configuration assembly 204 and model assembly 206.

FIG. 3 is a class hierarchy diagram of the equipment configuration class which is used to define equipment configuration objects within the equipment configuration assembly 204 of FIG. 2 in the preferred embodiment of the present invention. The equipment configuration class hierarchy comprises an EquipmentConfiguration base class 302 from which derived classes CompositeEquipment 304 and Equipment

306 are created. Hereinafter, the term "interface" is used to refer to a set of functions and related variables for implementing the interface. The equipment class 306 is used for creating equipment objects to represent a single unitary piece of equipment. The equipment class 306 further defines the engineering interface of the base Equipment-Configuration base class 302 so that it is specific for representing a unitary piece of equipment. The CompositeEquipment class 304 is used for equipment which comprises other equipment (equipment sub-pieces) such as an assembly. The CompositeEquipment class 304 further defines the engineering interface of the EquipmentConfiguration base class 302 so that it is specific for representing an assembly. The CompositeEquipment class 304 further includes a ChildManagement interface for managing the equipment sub-pieces. The equipment sub-pieces may be either CompositeEquipment or Equipment objects. An assembly may be, for example, a cellular base station having a plurality of racks each having a radio. The cellular base station may be represented by a first CompositeEquipment object having ChildManagement over a plurality of second CompositeEquipment objects each of which represents an individual rack. The plurality of second Equipment objects each having ChildManagement of an equipment object which represents a radio.

The subject interface of the Equipment-Configuration base class 302 is inherited by the

derived classes CompositeEquipment 304 and Equipment 306. The subject interface is responsible for notifying subscribing model objects of changes made to the CompositeEquipment 304 or Equipment 306 objects. The subject interface is responsible for notifying subscribing models of changes made to the EquipmentConfiguration class 302. The subject interface comprises the following functions: subscribe, unsubscribe, notify, and readState. An example of the interface is illustrated in C++ in Table I below.

TABLE I

```
/* subject interface */
  void Subscribe(Observer);
  void Unsubscribe (Observer);
  void Notify ();
  State ReadState ();
  State state;
  Set <Observers> observers;
```

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The notification of model objects created from the model hierarchy 206 is implemented by a process which utilizes a subscriber/notify protocol. Model objects which require notification of changes must subscribe to an associated CompositeEquipment or Equipment object. The subscription of model objects to an associated CompositeEquipment or Equipment object ("subscribed object") is implemented by the subscribe function. A model object may also unsubscribe by utilizing the unsubscribe function in the subscribed object. The

subscribe function stores an identification of a subscribing model object in a C++ collection. In contrast, the identification of a model object is purged from the collection during execution of the unsubscribe function.

The notification to a subscribing model object of changes which are made to the subscribed object is implemented by the notify function. The notify function uses the collection within the subscribed object to notify all the model objects which have subscribed. The notify function invokes an update function within a subscribing model object's observer interface in order to perform the notification of the model object. An example of how the notify function may be implemented in pseudo code is illustrated in Table II below.

TABLE II

```
void Equipment configuration::Notify() {
     for each subscribing model in the collection
          invoke the subscribing models update
          function;

}
```

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The engineering interface is generally responsible for describing the placement, containment, connections, and settings for the associated equipment. An example of the engineering interface is illustrated in C++ in Table III below.

TABLE III

```
/* interface Engineering */
/* configuration management */
     void Add( EquipmentConfiguration );
     void Remove( EquipmentConfiguration );

     EquipmentConfiguration GetParent();
     void SetParent( EquipmentConfiguration );

     void RemoveDropSite( DropSite );
     void AddDropSite( DropSite );

/* attribute management */
     AttributeValue* Lookup( String );
     void AddAttributeValue( AttributeValue );
     void RemoveAttributeValue( AttributeValue );

/* connector management */
     void AddConnector( Connector );
     void RemoveConnector( Connector );
```

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In the preferred embodiment of the present invention the EquipmentConfiguration base class 302, CompositEquipment class 304 and Equipment class 306 are classes in C++. It would be obvious for a person of ordinary skill in the art that other computer programming language structures may also be utilized to implement the above C++ classes. The derived classes CompositeEquipment 304 and Equipment 306 are used for creating a hierarchy of objects for representing an assembly. For example, a hierarchy of objects may be created for a building (assembly) having a plurality of floors, each floor having a plurality of rooms, each

room having an individual piece of furniture. The building hierarchy may be implemented by a CompositEquipment object which represents the building and has ChildManagement over a plurality of Composite-Equipment objects each representing a floor, each floor CompositEquipment object having ChildManagement over a plurality of CompositEquipment objects each representing a room, each room CompositeEquipment object having ChildManagement over an Equipment object representing an individual piece of furniture. Hereinafter, objects which are created from the CompositEquipment or Equipment class are referred to as "equipment configuration objects".

The EquipmentConfiguration base class 302 has an equipment description 202 (FIG. 2) associated with it. Therefore, by definition, the derived classes CompositEquipment 304 and Equipment 306, and objects created from them, also have an associated individual equipment description. The equipment description 202 defines and stores information about an associated piece of equipment. The information may include the physical attributes of the equipment, associated graphic presentations, and connectivity and configuration information. The physical attributes of the equipment may, for example, include dimensions, weight, and power requirements. The information on associated graphic presentations may, for example, include how the equipment will appear within different types of drawings, such as plans and elevations. The

connectivity information may include associated compatible equipment. The configuration information may include drop-sites which define the correct position or orientation for compatible equipment. For example, a cellular radio may only be placed in certain positions and orientations on certain shelves within a radio base station cabinet. A drop-site associated with the cabinet would define a location, size and transformation for the cellular radio.

Referring again to FIG. 2, the model assembly 206 is used to describe the various elements that comprise an engineering drawing. Each equipment configuration object has at least one associated model object. A model object generally comprises graphical or textual representations of the equipment configuration object. The graphical and textual representations vary depending upon the particular types of drawings, such as a floor plan, an elevation or building materials. The graphical representation may also include textual annotations indicative of the author, the document revision number, the project, and associated data. Dimensioning information, which describes the physical relationships of the equipment, and graphical information, such as circles and rectangles utilized to draw arrows, borders and highlights, may also be included.

Referring now to FIG. 4, a class hierarchy block diagram of the model class hierarchy 206 of FIG. 2 is illustrated. The model class hierarchy 206 comprises

a Model base class 402, a GraphicModel base class 404, an EquipmentModel base class 406, a CompositEquipment-Model class 408, an EquipPlanModel class 410, an EquipElevModel class 412, a CompositeGraphicModel class 420, a LineModel class 418 and a RectModel class 416.

The model class 402 is a base class from which graphic model class 404 is created. The model class 402 comprises an observer interface, a subject interface, and a command interface. The graphic model 404 is a base class from which the classes EquipmentModel 406, CompositeGraphicModel 420, LineModel 418 and RectModel 416 are created. The GraphicModel 404 base class further defines the observer and subject interfaces of the model base class 402. The derived classes CompositeGraphicModel 420, LineModel 418 and RectModel 416 are created from the GraphicModel base class 404, and further define the observer and command interfaces of the graphic model 404. The EquipmentModel class 406 is a base class created from the GraphicModel class 404, and further defines the observer and command interfaces of the GraphicModel base class 404. The derived classes composite EquipmentModel 408, EquipPlanModel 410 and EquipElevModel 412 are created from the EquipmentModel base class 406, and further define the observer and command interfaces of the EquipmentModel base class 406. Hereinafter, objects which are created from the derived classes composite EquipmentModel 408,

EquipPlanModel 410 and EquipElevModel 412 are referred to as "model objects".

An assembly, such as, for example, a cellular base station, may include a plurality of equipment sub-pieces, such as a plurality of racks each having a plurality of shelves each having a radio. The cellular base station may be represented by a first CompositEquipment object having ChildManagement over a plurality of second CompositEquipment objects, each of which represents an individual rack. The plurality of second compositeequipment objects each has ChildManagement over an equipment object which represents a radio. A model object exists for the first CompositEquipment object, each one of the second CompositEquipment objects, and each of the Equipment objects.

Model objects may also be utilized to illustrate the various aspects of the equipment configuration objects. For example, in the preferred embodiment of the present invention, physical model objects are used to illustrate the arrangement of hardware and cabling. Logical model objects may also be implemented to illustrate the logical connections between components.

Since various model objects may be utilized to illustrate different aspects of equipment objects, certain assembly equipment sub-pieces will not appear within different model objects. For example, FIG. 5 is a block diagram illustrating an example of a physical model object 502 and a logical model object 504, each

representing one base station assembly in the preferred embodiment of the present invention. The physical model object 502 comprises a base station model object 506, a rack model object 508, a shelf model object 510, and radio model objects 512 and 514. The logical model object 504 comprises the base station model object 506 and the radio model objects 512 and 514. The logical model object 504 does not illustrate the rack model object 508 or the shelf model object 510, since shelves and racks by definition do not participate in the logical model object 504. A person of ordinary skill in the art could easily create additional model classes without departing from the scope of the present invention. For example, a plan model or elevation model of a site or an individual piece of equipment may be added.

Each model object is responsible for utilizing the subscribe function in an associated equipment configuration object in order to be notified of changes within the equipment configuration object. In the preferred embodiment of the present invention, the class models 402-420 (FIG. 4) are implemented as classes in C++. However, it would be obvious to a person of ordinary skill in the art that other computer programming language structures may be utilized to implement class models 402-420.

Referring again to FIG. 4, the class model 402 comprises observer, command, and subject interfaces. The observer interface is utilized for responding to a

received "notify" request from an associated equipment configuration object. The observer interface comprises an update function which is invoked by an equipment configuration object with which the model class 402 has subscribed. An example of how the update function may be implemented in C++ is illustrated in Table IV below.

TABLE IV

```
void model::Update()
{/* observer Interface for model */
     state s;
     s = subject.state;
 /* change internal state to be consistent with
     Subject */
}
```

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The command interface is used to interpret and respond to commands received by the tools unit 214 (FIG. 2). The subject interface is identical to the subject interface implemented by the equipment configuration class 302 (FIG. 3), except for the fact that view objects use the model class's 402 subject interface to subscribe model objects.

The above discussion concerning the observer, subject and command interfaces which is made in reference to the model class 402 is equally applicable to class models 404-420.

Each model object must use a view object in order to be graphically illustrated. View objects are

mechanisms which present visual representations of model objects to the user, and which also provide means by which users can manipulate the equipment. There is a one-to-one correspondence between elements in a model object and elements in a view object. Each view object used for graphically illustrating a model object is required to subscribe to the model object.

Referring now to FIG. 6, a class hierarchy block diagram of the view class which is used to define view objects within the view assembly 208 of FIG. 2. The view class hierarchy comprises a view class 602, a CompositEquipmentview class 604, an equipmentview class 606, an equipplanview class 608, an equipelevview class 610, a compositegraphicview class 612, a lineview class 614, and a rectview 616 class. The view class 602 is an abstract class comprising an observer and tools interface. The derived classes CompositEquipmentView 604, CompositeGraphicView 612, Lineview 614, and Rectview 616 are created from the view base class 602, and further define the observer and tools interfaces. The equipmentview class 606 is a base class created from the view base class 602, and further defines the observer and tools interfaces. The derived classes equipplanview 608 and equipelevview 610 are created from the equipmentview base class 606, and further define the observer and tools interfaces of the base class. Hereinafter, objects created from the derived classes CompositEquipmentview 604, equipplanview 608

and equipelevview 610 are referred to as "view objects".

A view object performs the following functions: (1) determining a particular presentation of the equipment which includes how or when to display the presentation; (2) managing the layering and the selective display of the equipment; (3) defining view-specific connection and manipulation semantics of equipment; and (4) structuring the view object itself according to the structure of the equipment within the model hierarchy and connections. View objects also provide spacial indexing hit detection, view structure management, and scaling and transformations. View objects also manage presentations including structure transformations and mapping between a graphic system and an equipment editor. View objects also interpret individual tools within the tool unit 214 (FIG. 2) in order to create a manipulator. In addition, CompositEquipmentView objects must provide cached extents for hit detection and selective redraw.

The separation of the view hierarchy from the model hierarchy allows multiple view objects to be associated with an individual model object, each one of the view objects displaying a different portion of the model object. Each one of the multiple view objects automatically reflects updates made within an associated view object. For example, if a rack is moved in one view object, it will automatically move within an associated view object. The separation of

the view hierarchy from the model hierarchy decouples the semantics of model objects from the semantics of direct manipulation which are provided by view objects. For example, the arrangement of network elements within a CompositEquipment view object which is associated with a logical CompositEquipment model object may be interactively modified by a user in order to make the CompositEquipment view object more graphically appealing. However, since no elements have been added, removed or reconnected, a network CompositEquipment model object which is also associated with the CompositEquipment object would remain unaffected.

In the preferred embodiment of the present invention the classes view 602, composite equipment view 604, equipmentview 606, equipplanview 608, equipelevview 610, compositegraphicview 612, line view 614, and rect view are implemented as classes in C++. However, it would be obvious to a person of ordinary skill in the art that other computer programming language structures may be utilized to implement the above classes.

The observer interface in the view class 602 is used for responding to a received notify request, from an associated model object, by updating the view class 602 accordingly. The observer interface comprises an update function which is invoked by a model object with which the view class 602 has subscribed. An example of how the update function may be implemented in C++ is illustrated in Table V below.

TABLE V

```
void view::Update() {
     State s;
     s = model.state;
     /* change internal state to be
          consistent with model */
}
```

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The tools interface in the view class 602 is responsible for creating the manipulator 212 in response to a request from the tools unit 214. Additionally, the tool interface interprets the created manipulator 212 in order to create associated commands.

The above discussion concerning the observer and tools interfaces which is made in reference to view class 602 is equally applicable to class views 604-610.

Each view object must have an associated graphic presentation ("presentation"). The presentation is responsible for managing the display of the view object to the terminal, and for translating actions performed on the view object. The presentation may graphically illustrate, for example, a view in 3-D for physical model objects, as icons for electrical and network model objects, or as text in a spreadsheet for economic model objects. The presentation is also responsible for maintaining graphical integrity within an associated larger presentation of the model object. This typically involves moving and changing attributes such as scale and color.

In addition, the presentation manages the details of underlying graphic and windowing systems, such as exposure processing. For example, if a portion of an associated view object becomes distorted or corrupted (e.g., resulting from another window which previously overlayed the view and subsequently was removed) the presentation re-renders (refreshes) the distorted portion of the view object. In the preferred embodiment of the present invention, an object oriented graphics library which contains routines for two and three dimensional displays is employed. The graphics library may be, for example, HOOPS which is produced by Ithaca Software Inc. The HOOPS graphics library comprises a set of graphic C++ classes which implement graphic primitives such as a rectangle, a line, a circle and text in the underlying graphics system. A HOOP segment is used as a presentation for a view object. A view object manages the segment's location and properties within a HOOP segment structure which represents an associated model object.

By separating the presentation 214 from the associated view object, the manipulation semantics are decoupled from the rendering mechanisms. This allows the underlying graphic mechanisms to be changed in the future without having to redesign the classes within the view class hierarchy. For example, changing from a HOOPS graphics system to a PEX graphics system can be effected without having to redesign the classes within the view class hierarchy. The separation of the

presentation from individual view objects also provides the user with the ability to easily change the graphical symbols utilized to represent the equipment. For example, a simple box symbol may be replaced with a more realistic and detailed graphical symbol. In addition, the separation provides simple default displays (e.g. empty rectangles) if no presentation currently exists for a view object.

FIG. 7 is an example of an editor 224 which might appear on the graphics terminal 12 of FIG. 1 in the preferred embodiment of the present invention. The editor 224 comprises the tools unit 214 which allows the user to graphically create and modify the equipment catalog 216 (FIG. 2), equipment description 202, equipment configuration assembly 204, model assembly 206, and site catalog 218. In the preferred embodiment of the present invention, a "create model" tool is utilized for introducing new model objects. Each individual tool within tools 214 utilizes manipulators to define graphical feedback, such as rubber banding and snap-dragging, during the utilization of the individual tool. Manipulators provide semantics for direct manipulation.

FIGS. 8A-8B together form an interaction diagram which illustrates the steps involved in updating a model object from the editor 224 of FIG. 7 in the preferred embodiment of the present invention. Referring now to FIG. 8A, at step 802, an event is received from the processor 26 (FIG. 1) indicating that

an individual tool has been selected from the tools unit 214 (FIG. 7). The viewer 212 (FIG. 2) receives the event and requires the tools unit 214 to create a manipulator 211 at step 804. The tools unit 214 defers the creation responsibility to a view object at step 806. The view object creates the manipulator 212 at 807. The manipulator 212 interacts with the viewer 402 at step 808 to receive and interpret actions by the user, provide graphic feedback, and record details of the interaction. Once the user has completed their use of the manipulator 211, the manipulator 211 provides details of the interaction to a view object. The view object instructs the tools 214 to create a command associated with the details at step 810. The tools unit 214 defers the creation of the command to view object at step 812. The view object creates the command at step 820, and de-allocates the created manipulator 211 at step 814. The created command is placed on the viewer's 212 history list and executed at step 818.

Referring now to FIG. 8B, the executed command is received by a model object which interprets the command at step 904. The model object communicates the interpretation to an associated CompositEquipment or Equipment object ("equipment configuration object") at step 906. The equipment configuration object notifies all subscribing model objects if any changes have resulted from the interpretation at step 908. The notification is performed by invoking the update

function within subscribing model objects at step 910. The notify function in the subscribing model objects reads the state of the equipment configuration object, and updates itself accordingly at step 912. The model objects then notify subscribing view objects at step 914, by invoking the update function in the view objects at step 916. The view objects read the state of associated model objects and update themselves accordingly at step 918. The view object then modify associated presentations to reflect the update at step 920.

The command used in the above process is responsible for coordinating with database 228 (FIG. 2) for the reading and writing of data associated with the equipment description 202, the equipment objects and model objects.

FIG. 9 is an example of two cellular sites which may exist within database 228 using the method and system of the present invention. Database 228 may be used, for example, for organizing and maintaining information related to two cellular sites 1010 and 1012, equipment description 1020, equipment catalog 1022 and site catalog 1024. In addition, database 228 is used for maintaining various revisions of cellular sites 1010 and 1012. Cellular site 1010 comprises an equipment assembly 1002 and a plurality of model objects 1004-1008. Cellular site 1012 comprises equipment assembly 1002 and a plurality of model objects 1016-1018. The equipment description assembly

comprises a plurality of equipment description objects which have associated equipment objects within the equipment assembly 1002. The equipment description 1020 is stored within equipment catalog 1022. Cellular sites 1010 and 1020 are stored within the site catalog 1024. The equipment assembly 1002 comprises a plurality of equipment configuration objects which collectively represent the hierarchy of sites 1010 and 1012.

FIG. 10 is a diagram which illustrates the hierarchy of equipment configuration objects which may exist within the equipment assembly 1002 of FIG. 9, and each of the equipment configuration objects relationship with the equipment description 1020 of FIG. 9. The equipment assembly 1002 may be comprised of CompositEquipment objects 1102-1114. Each one of the CompositEquipment objects 1102-1114 have an associated equipment description, within the equipment description 1020, which is stored within the equipment catalog 1022. For example, CompositEquipment objects 1102, 1104, 1106 and 1114 have related equipment descriptions 1126, 1128, 1132 and 1134, respectively, within the equipment description 1020.

Each one of the CompositEquipment objects 1102-1114 may be comprised of additional CompositEquipment objects and equipment objects. For example, CompositEquipment object 1104 may represent a base station having a plurality of cabinets, with each cabinet having a plurality of racks, and each rack

having a plurality of radios. CompositEquipment object 1106 represents one such cabinet and exercises ChildManagement over a plurality of CompositEquipment objects each representing an individual rack. CompositEquipment object 1114 represents one such rack and exercises ChildManagement over a plurality of radios represented by equipment objects 1116-1122, each of which has an associate equipment description 1136 within the equipment description assembly 1020.

Referring now to FIG. 11, there is shown a diagram which illustrates a plurality of equipment, model, view and graphic assemblies having a plurality of equipment, model, view and graphic objects, respectively, and an associated presentation for the cabinet 1106 of FIG. 10. CompositEquipment object 1106 and rack CompositEquipment object 1114 are represented by CompositEquipment model objects 1210 and 1208, respectively. Radio equipment objects 1116, 1118 and 1120 are represented by equipment model objects 1206, 1202 and 1204, respectively. In addition, a textmodel object 1212, a pagemodel object 1214 and a RectModel object 1216 are also used. The model objects 1202-1214 are used to construct a presentation from view and graphic objects which is graphically illustrated on graphics terminal 12 of FIG. 1.

The pagemodel object 1214, textmodel object 1212, RectModel object 1216, composite equipmodel objects 1208-1210, and EquipmentModel objects 1202-1204 are associated with a pageview object 1220, a textmodel

object 1222, a rectview object 1224, CompositEquipment view objects 1226-1228, and equipmentview objects 1230-1234, respectively. The pageview object 1220, textview object 1222, rectview object 1224, CompositEquipment-View objects 1226-1228, and equipmentview objects 1230-1234 are associated with pageviewgraphic object 1240, textgraphic object 1242, rectgraphic object 1248, CompositEquipment graphic objects 1246 and 1250, and equipment graphic objects 1254-1258, respectively. The graphic objects 1240-1258 are graphically represented in presentation 1270.

The subscribe/notify links between the various objects is as follows: (1) the graphic objects 1240-1258 subscribe to their associated view objects 1220-1234; (2) the view objects 1220-1234 subscribe to their associated model objects 1202-1216; and (3) the model objects 1202-1216 subscribe to their associated equipment objects 1106 and 1114-1120.

Referring now to FIG. 12, there is illustrated an example of various methods for interfacing with the database 228 of FIG. 1. Database 228 may interface with a direct access through a direct access system such as 1302. The direct access system 1302 accesses the database 228 by using a common protocol in order to obtain information from the various components contained therein.

A remote system interface 1308 to database 228 comprises a first Object Request Broker (ORB1) 1304 and a second Object Request Broker (ORB2) 1306. The remote

system 1308 utilizes the ORB1 1304 ORB2 1306 to access the various components of database 228. ORB1 1304 and ORB2 1306 may be, for example, International Business Machine's System Object Model (SOM) or a similar object model such as Component Object Model (COM) developed by Microsoft Inc. .

A computer program listing which implements the method and system of the present invention is attached hereto as Appendix A.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description. While the method shown and described has been characterized as being preferred, it will be readily apparent that various changes and modifications could be made therein without departing from the spirit and scope of the invention as defined in the following claims.

WHAT IS CLAIMED IS:

1. A method of implementing an intelligent graphical representation of equipment within a computer modeling system having a memory, a processor, a visual display, and an input device, said method comprising the steps of:

representing said equipment in an equipment configuration object which defines the placement of said equipment within a compatible component, and specifies connections between said equipment and said compatible component;

defining physical attributes of said equipment in an individual equipment description object;

associating said equipment configuration object with said equipment description object;

defining display characteristics of said equipment configuration object in a model object; and

subscribing said model object with said equipment configuration object so that said model object is notified of changes to said subscribed equipment configuration object.

2. The method of claim 1 further comprising the step of providing means for graphically displaying said model object on said visual display.

3. The method of claim 2 wherein said step of providing means for graphically displaying said model object on said visual display includes the steps of:

providing a plurality of view objects, each of said view objects determining a graphical illustration for said model object on said visual display;

subscribing each of said plurality of view objects with said model object so that said plurality of view objects are notified of changes to said subscribed model object;

creating a presentation object for each of said plurality of view objects, each of said presentation objects graphically illustrating one of said view objects on said visual display;

subscribing each of said presentation objects with a different one of said plurality of view objects so that said presentation objects are notified of changes to said subscribed plurality of view objects; and

providing a user with means for graphically selecting and manipulating said plurality of view objects.

4. The method of claim 3 wherein said step of creating a presentation object includes the step of:

creating a presentation object from a graphics library for each of said plurality of view objects, each of said presentation objects graphically illustrating one of said plurality of view objects on said visual display.

5. The method of claim 4 wherein said step of creating a presentation object includes the step of:

creating a presentation object from an object oriented graphics library for each of said plurality of view objects, each of said presentation objects graphically illustrating one of said plurality of view objects on said visual display.

6. The method of claim 3 wherein said step of providing a user with means for graphically selecting and manipulating said view objects includes the steps of:

providing an editor comprising a tools unit and a viewer, said tools unit comprising a plurality of tools for graphically interacting with said user via said input device; and

providing a manipulator object for receiving and translating events from said viewer to said view object.

7. The method of claim 1 further comprising the step of:

storing said equipment configuration object, said equipment description object, and said model object in a database.

8. The method of claim 7 wherein said storing step includes the step of:

storing said equipment configuration object, said equipment description object, and said model object in an object oriented database.

9. The method of claim 8 further comprising the step of providing means for modifying said database.

10. The method of claim 9 wherein said step of providing means for modifying said database includes the step of:

providing access to said database with a direct access system.

11. The method of claim 9 wherein said step of providing means for modifying said database includes the steps of:

providing a first object request broker for interfacing with said database;

accessing said first object request broker with a second object request broker; and

remotely accessing said second object request broker in order to modify said database.

12. The method of claim 1 further comprising the step of:

creating a plurality of said equipment configuration objects and said model objects to represent a site.

13. The method of claim 12 further comprising the step of:

creating and storing different versions of said site in said database.

14. The method of claim 1 further comprising the step of:

creating said equipment configuration object, said equipment description object, and said model object as individual classes in a C++ computer programming language.

15. A method of updating an equipment site within an intelligent computer modeling system, said equipment site being represented by a plurality of equipment configuration objects, each of said plurality of equipment configuration objects having a subscribing model object, said computer modeling system having a memory, a processor, a visual display, and an input device, said method comprising the steps of:

providing a tools unit comprising a plurality of tools for interacting with said input device;

receiving a selection event from said input device which indicates a selection of one of said plurality of tools;

creating a manipulator object in response to said received selection event;

receiving, in said manipulator object, a plurality of manipulator events from said input device which are associated with said selected tool;

interpreting said plurality of manipulator events within said manipulator object in order to provide graphical feedback to said visual display;

recording interactions between said input device and said selected tool;

transmitting a command, which corresponds to the recorded interactions, to at least one of said plurality of equipment configuration objects; and

updating said at least one of said equipment configuration objects in response to said command thereby updating said site.

16. The method of claim 15 further comprising the steps of:

notifying said plurality of subscribing model objects of changes to said at least one of said updated equipment configuration objects; and

updating each of said plurality of notified model objects to reflect changes to said at least one of said equipment configuration objects.

17. A system for implementing an intelligent graphical representation of equipment within a computer modeling setup having a memory, a processor, a visual display and an input device, said system comprising:

means for representing said equipment in an equipment configuration object which defines the placement of said equipment within a compatible component, and specifies connections between said equipment and said compatible component;

means for defining physical attributes of said equipment in an individual equipment description object;

means for associating said equipment configuration object with said equipment description object;

means for defining display characteristics of said equipment configuration object in a model object; and

means for subscribing said model object with said equipment configuration object so that said model object is notified of changes to said subscribed equipment configuration object.

18. The system of claim 17 further comprising means for providing means for graphically displaying said model object on said visual display.

19. The system of claim 18 wherein said means for providing means for graphically displaying said model object on said visual display includes:

means for providing a plurality of view objects, each of said view objects determining a graphical illustration for said model object on said visual display;

means for subscribing each of said plurality of view objects with said model object so that said plurality of view objects are notified of changes to said subscribed model object;

means for creating a presentation object for each of said plurality of view objects, each of said

presentation objects graphically illustrating one of said view objects on said visual display;

means for subscribing each of said presentation objects with a different one of said plurality of view objects so that said presentation objects are notified of changes to said subscribed plurality of view objects; and

means for providing a user with means for graphically selecting and manipulating said plurality of view objects.

20. The system of claim 19 wherein said means for creating a presentation object includes:

means for creating a presentation object from a graphics library for each of said plurality of view objects, each of said presentation objects graphically illustrating one of said plurality of view objects on said visual display.

21. The system of claim 20 wherein said means for creating a presentation object includes:

means for creating a presentation object from an object oriented graphics library for each of said plurality of view objects, each of said presentation objects graphically illustrating one of said plurality of view objects on said visual display.

22. The system of claim 21 wherein said means for providing a user with means for graphically selecting and manipulating said view objects includes:

means for providing an editor comprising a tools unit and a viewer, said tools unit comprising a plurality of tools for graphically interacting with said user via said input device; and

means for providing a manipulator object for receiving and translating events from said viewer to said view object.

23. The system of claim 17 further comprising:

means for creating a plurality of said equipment configuration objects and said model objects to represent a site.

24. The system of claim 23 further comprising:

means for creating and storing different versions of said site in said database.

25. A system for updating an equipment site within an intelligent computer modeling setup, said equipment site being represented by a plurality of equipment configuration objects, each of said plurality of equipment configuration objects having a subscribing model object, said computer modeling setup having a memory, a processor, a visual display, and an input device, said system comprising:

means for providing a tools unit comprising a plurality of tools for interacting with said input device;

means for receiving a selection event from said input device which indicates a selection of one of said plurality of tools;

means for creating a manipulator object in response to said received selection event;

means for receiving, in said manipulator object, a plurality of manipulator events from said input device which are associated with said selected tool;

means for interpreting said plurality of manipulator events within said manipulator object in order to provide graphical feedback to said visual display;

means for recording interactions between said input device and said selected tool;

means for transmitting a command, which corresponds to the recorded interactions, to at least one of said plurality of equipment configuration objects; and

means for updating said at least one of said equipment configuration objects in response to said command thereby updating said site.

26. The system of claim 25 further comprising:

means for notifying said plurality of subscribing model objects of changes to said at least one of said updated equipment configuration objects; and

means for updating each of said plurality of notified model objects to reflect changes to said at least one of said equipment configuration objects.

5

FIG.1

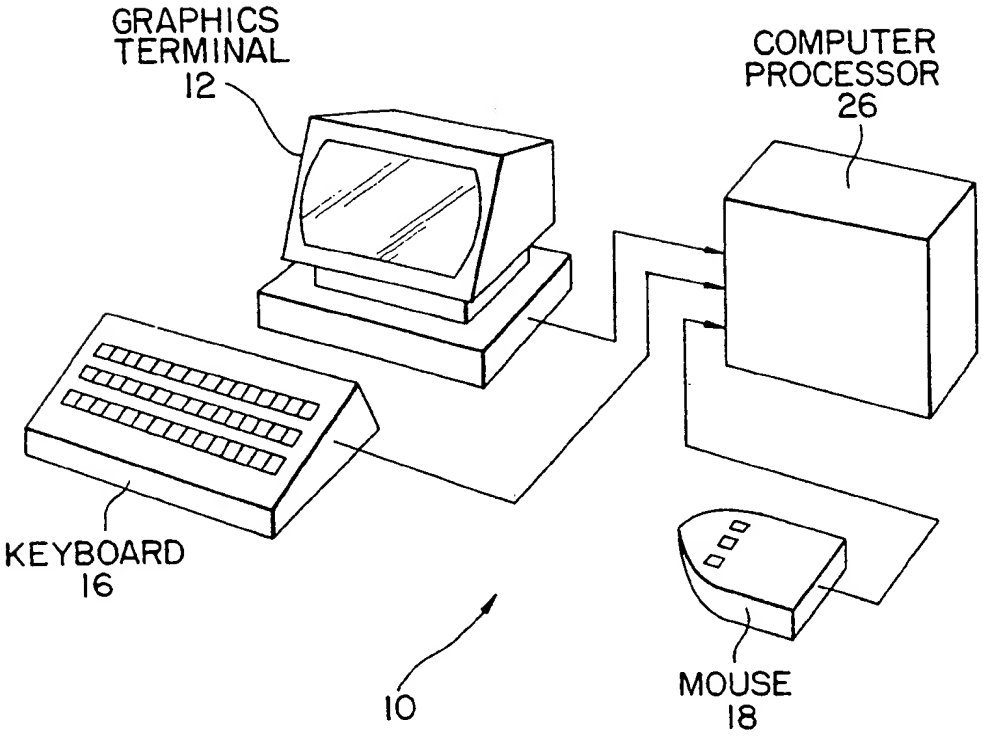

GRAPHICS
TERMINAL
12
COMPUTER
PROCESSOR
26
KEYBOARD
16
10
MOUSE
18

FIG.2

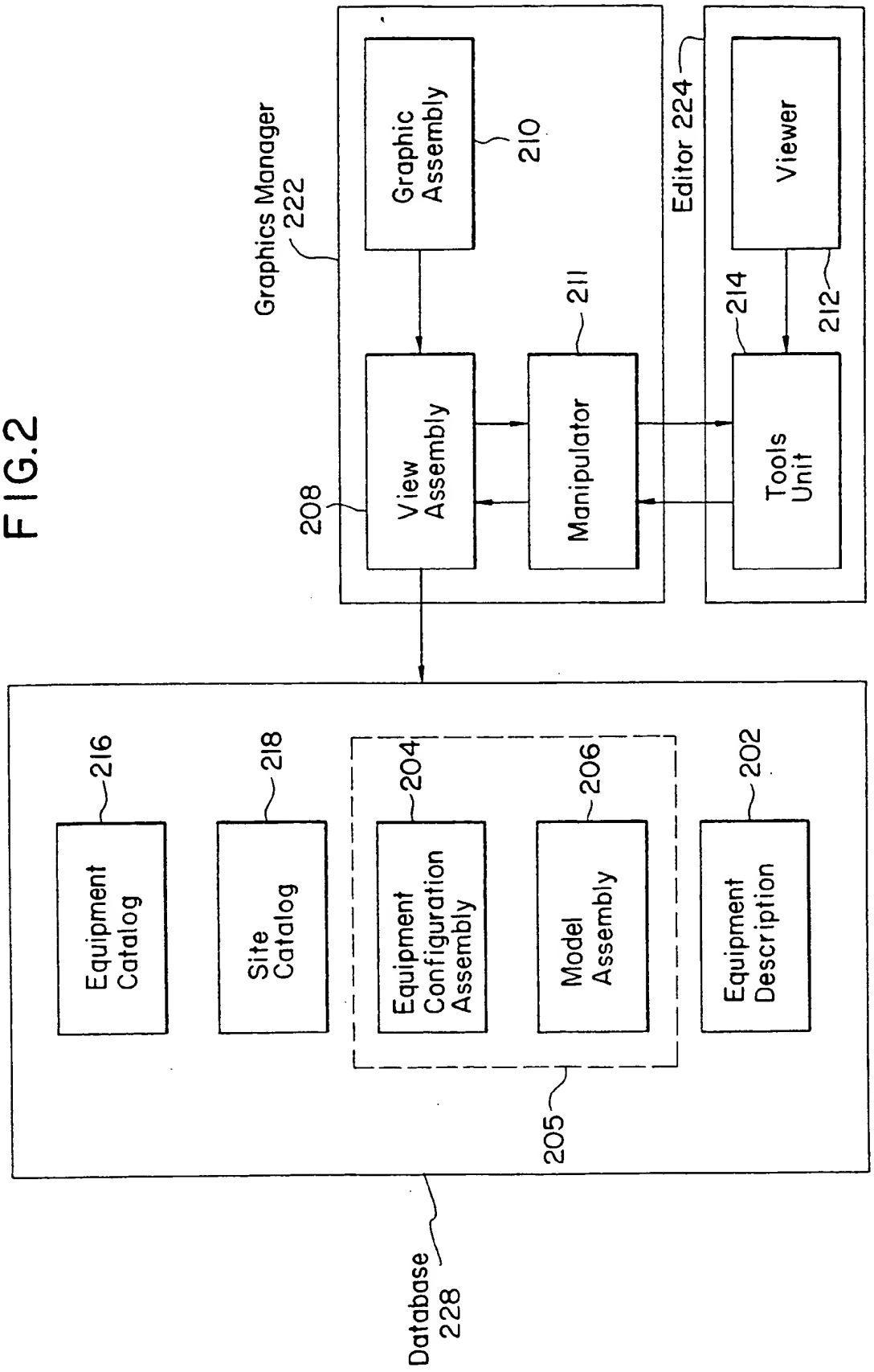
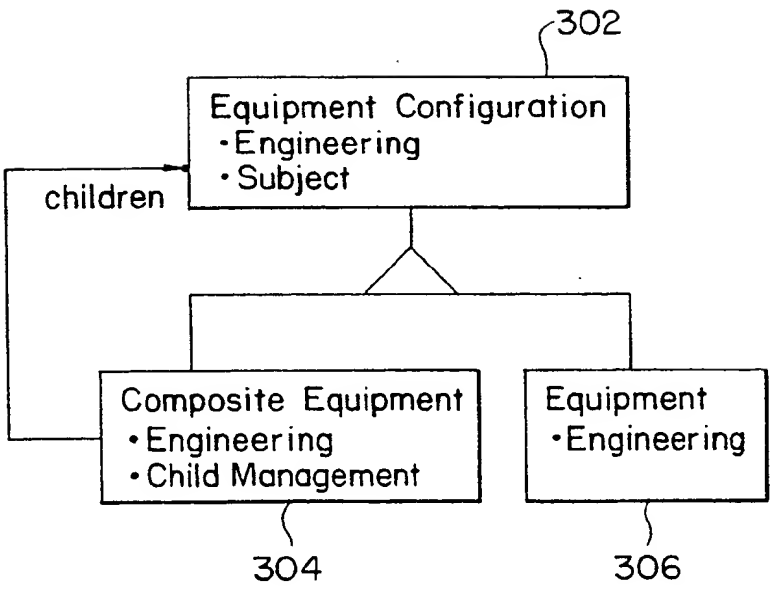

Graphics Manager
222
Graphic Assembly
210
Editor 224
Viewer
212
214
211
View Assembly
208
Manipulator
Tools Unit
Equipment Catalog
216
Site Catalog
218
Equipment Configuration Assembly
204
Model Assembly
206
Equipment Description
202
205
Database
228

FIG.3


302
Equipment Configuration
• Engineering
• Subject
children
Composite Equipment
• Engineering
• Child Management
Equipment
• Engineering
304
306

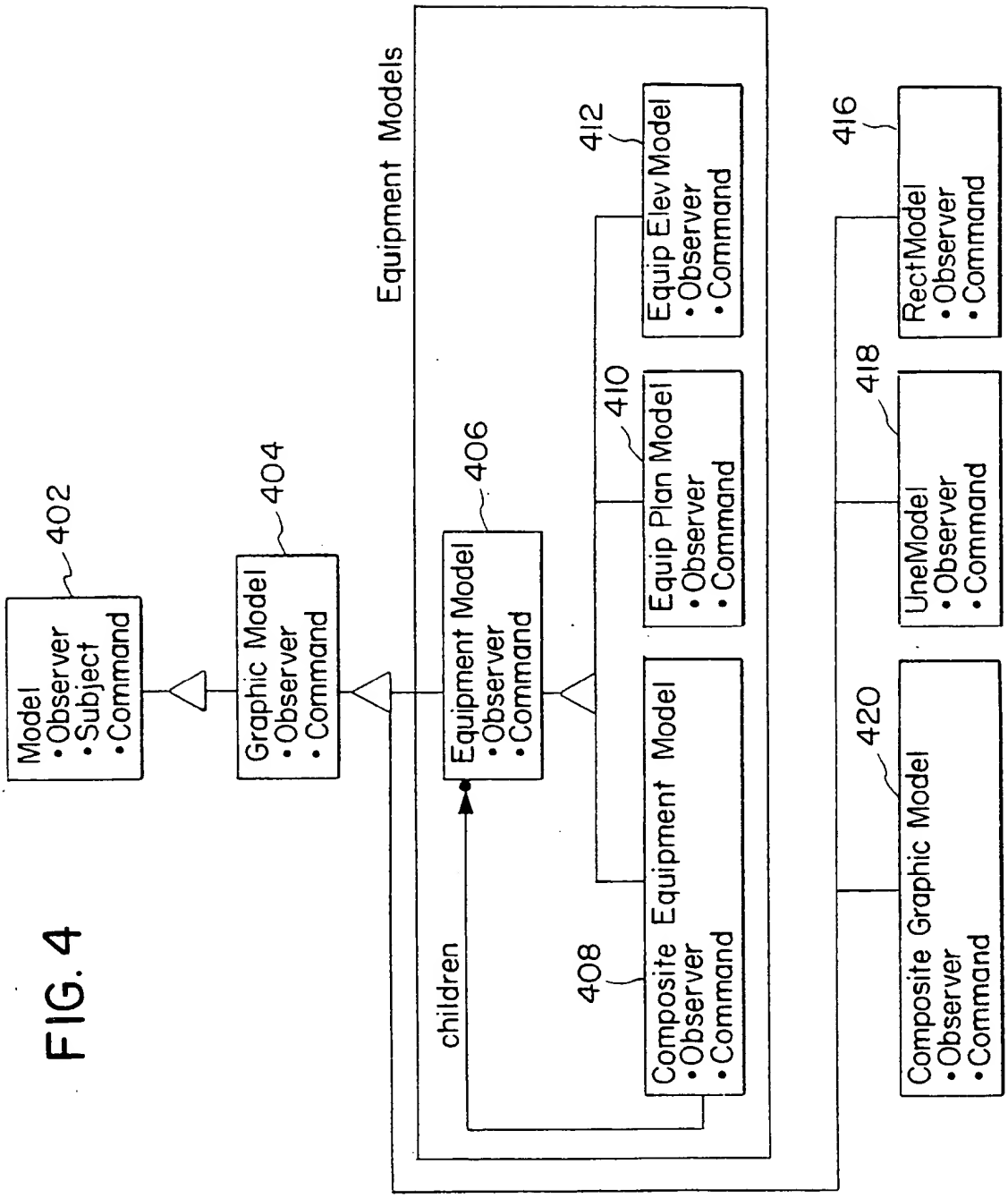
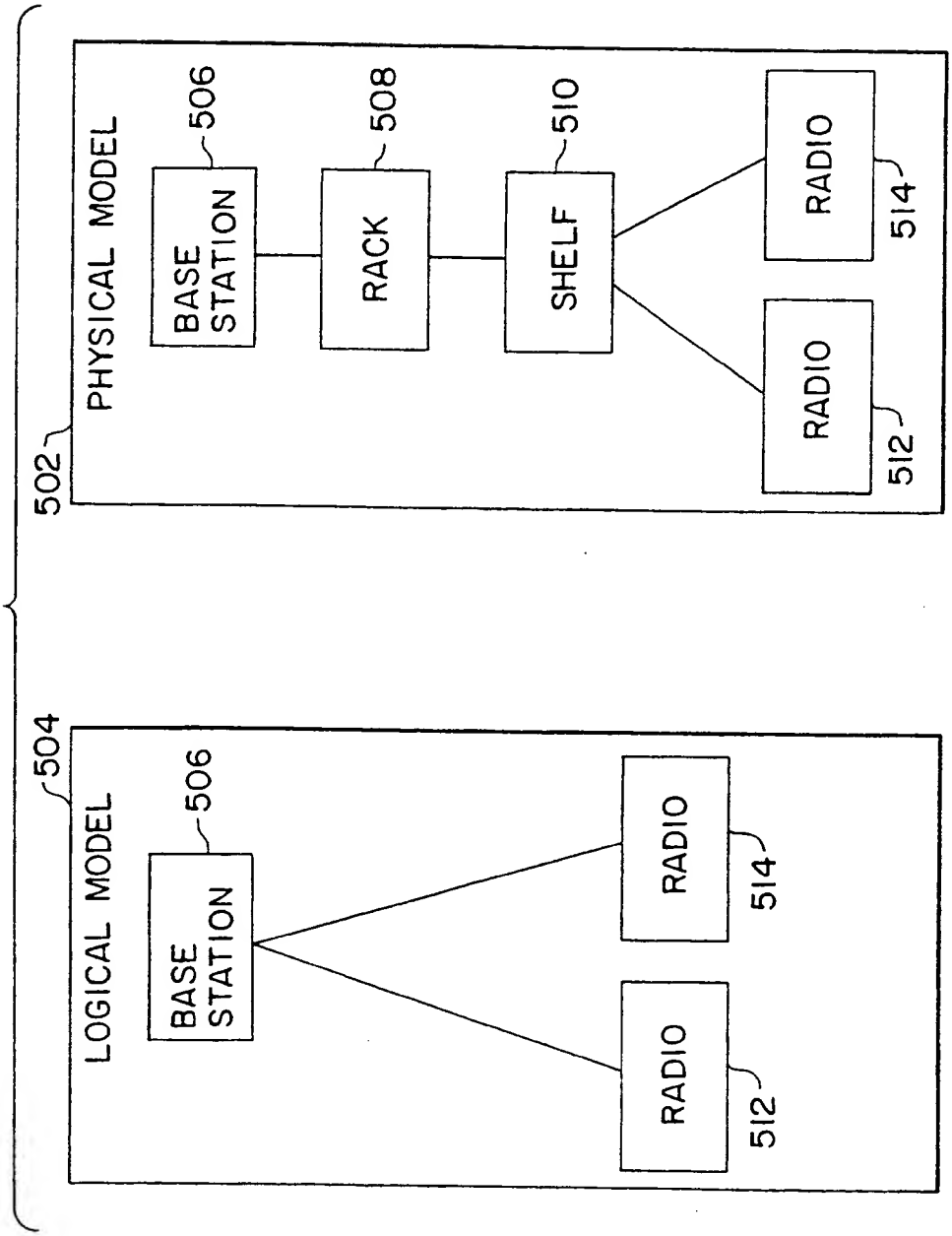

Model
•Observer
•Subject
•Command
402
Graphic Model
•Observer
•Command
404
Equipment Models
Equipment Model
•Observer
•Command
406
children
Composite Equipment Model
•Observer
•Command
408
Equip Plan Model
•Observer
•Command
410
Equip Elev Model
•Observer
•Command
412
Composite Graphic Model
•Observer
•Command
420
UneModel
•Observer
•Command
418
RectModel
•Observer
•Command
416

FIG. 4

FIG. 5


PHYSICAL MODEL
502
BASE STATION
506
RACK
508
SHELF
510
RADIO
514
RADIO
512
LOGICAL MODEL
504
BASE STATION
506
RADIO
514
RADIO
512

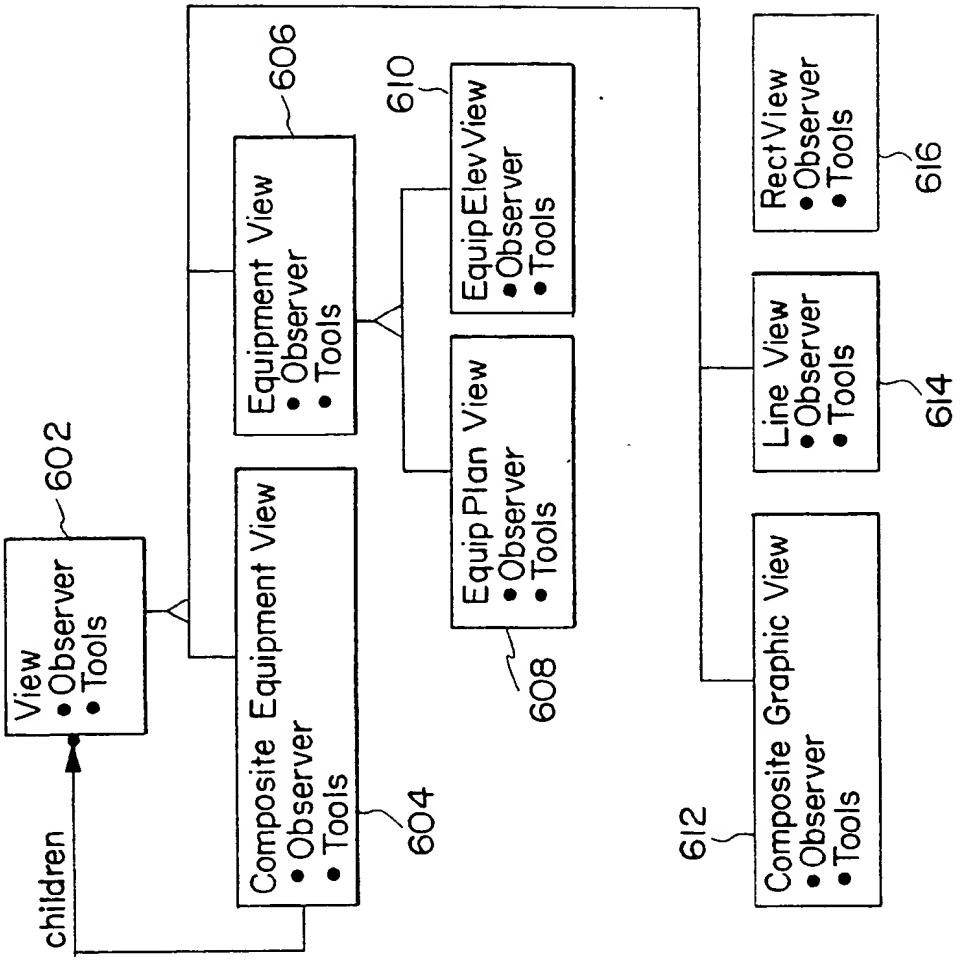

View
• Observer
• Tools
602
children
Composite Equipment View
• Observer
• Tools
604
Equipment View
• Observer
• Tools
606
Equip Plan View
• Observer
• Tools
608
EquipElevView
• Observer
• Tools
610
Composite Graphic View
• Observer
• Tools
612
Line View
• Observer
• Tools
614
RectView
• Observer
• Tools
616

FIG. 6

FIG.7

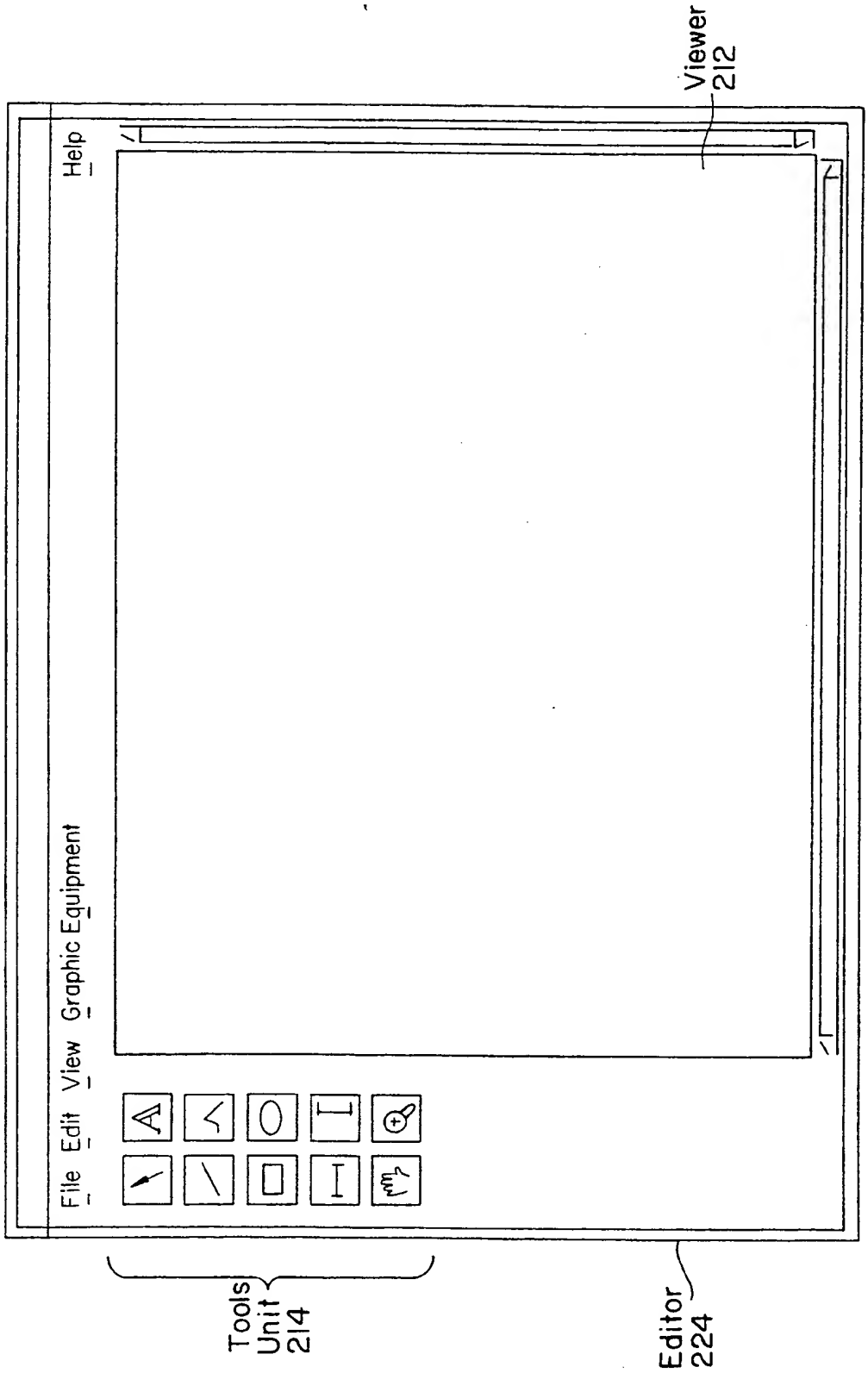

Viewer
212
Help
File Edit View Graphic Equipment
Tools
Unit
214
Editor
224

FIG. 8A

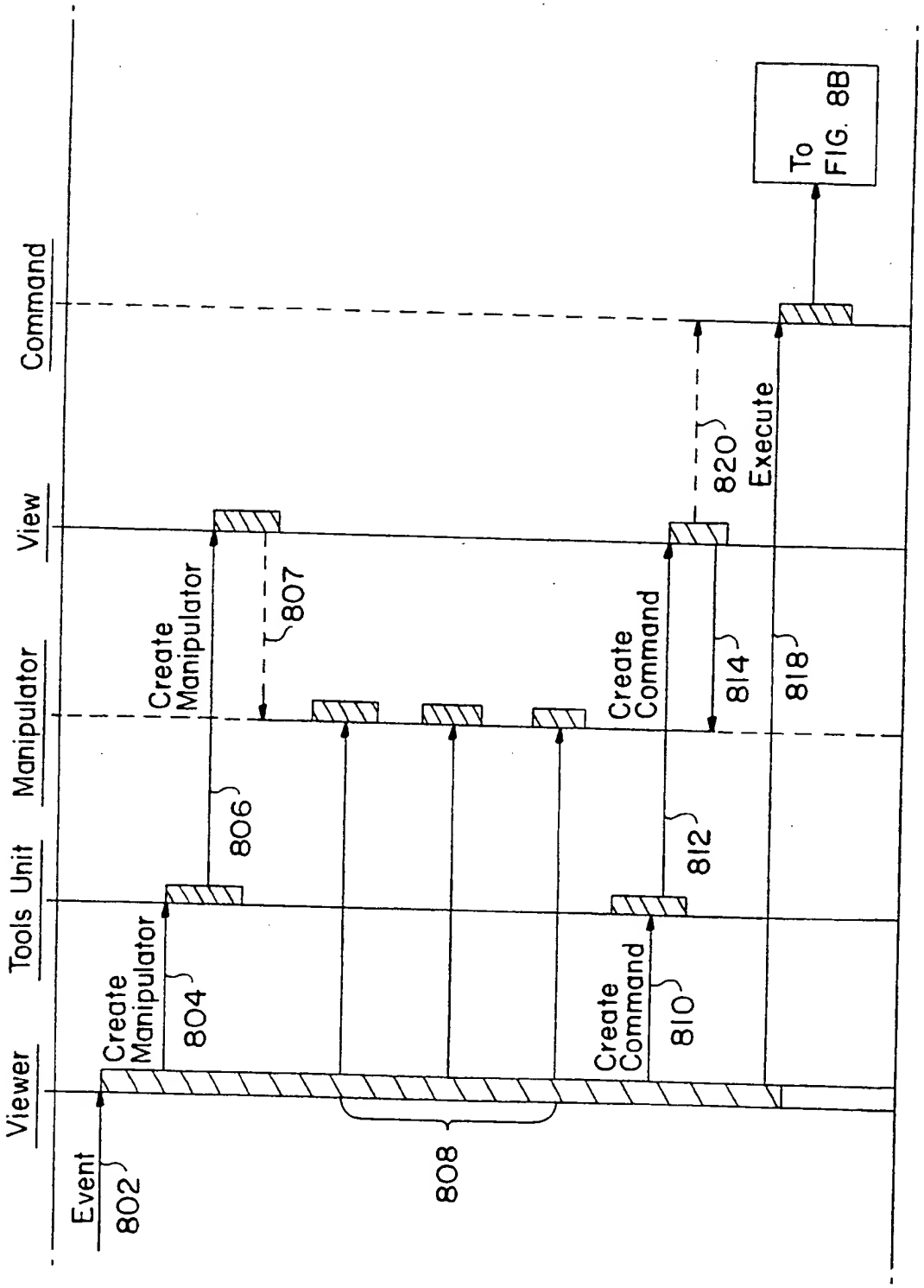
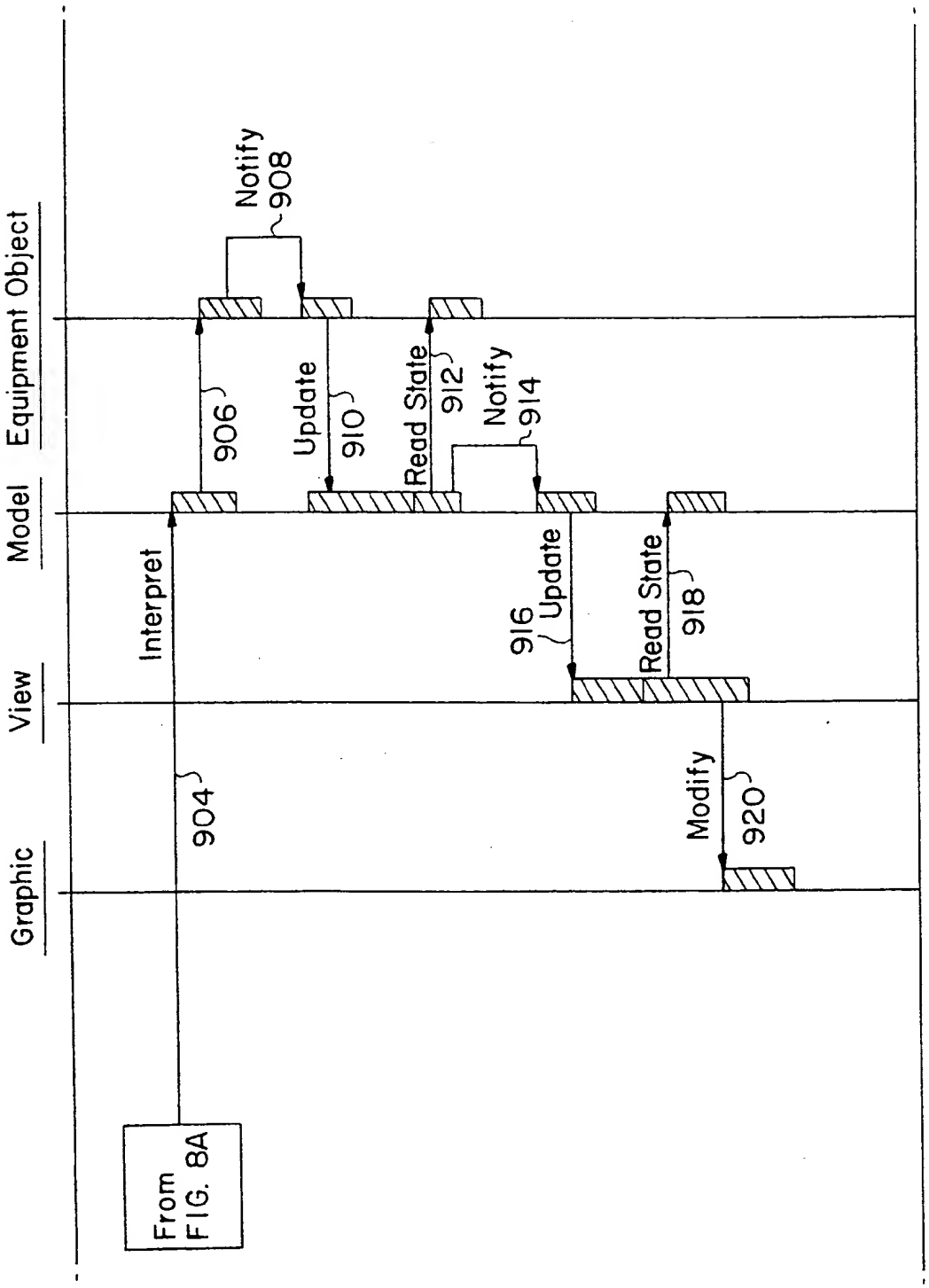

Viewer
Tools Unit
Manipulator
View
Command
Event
802
Create Manipulator
804
806
807
808
Create Command
810
812
814
818
820
Execute
To FIG. 8B

FIG. 8B


Graphic
View
Model
Equipment Object
From FIG. 8A
Interpret
904
Notify
908
906
Update
910
Read State
912
Notify
914
916
Update
Read State
918
Modify
920

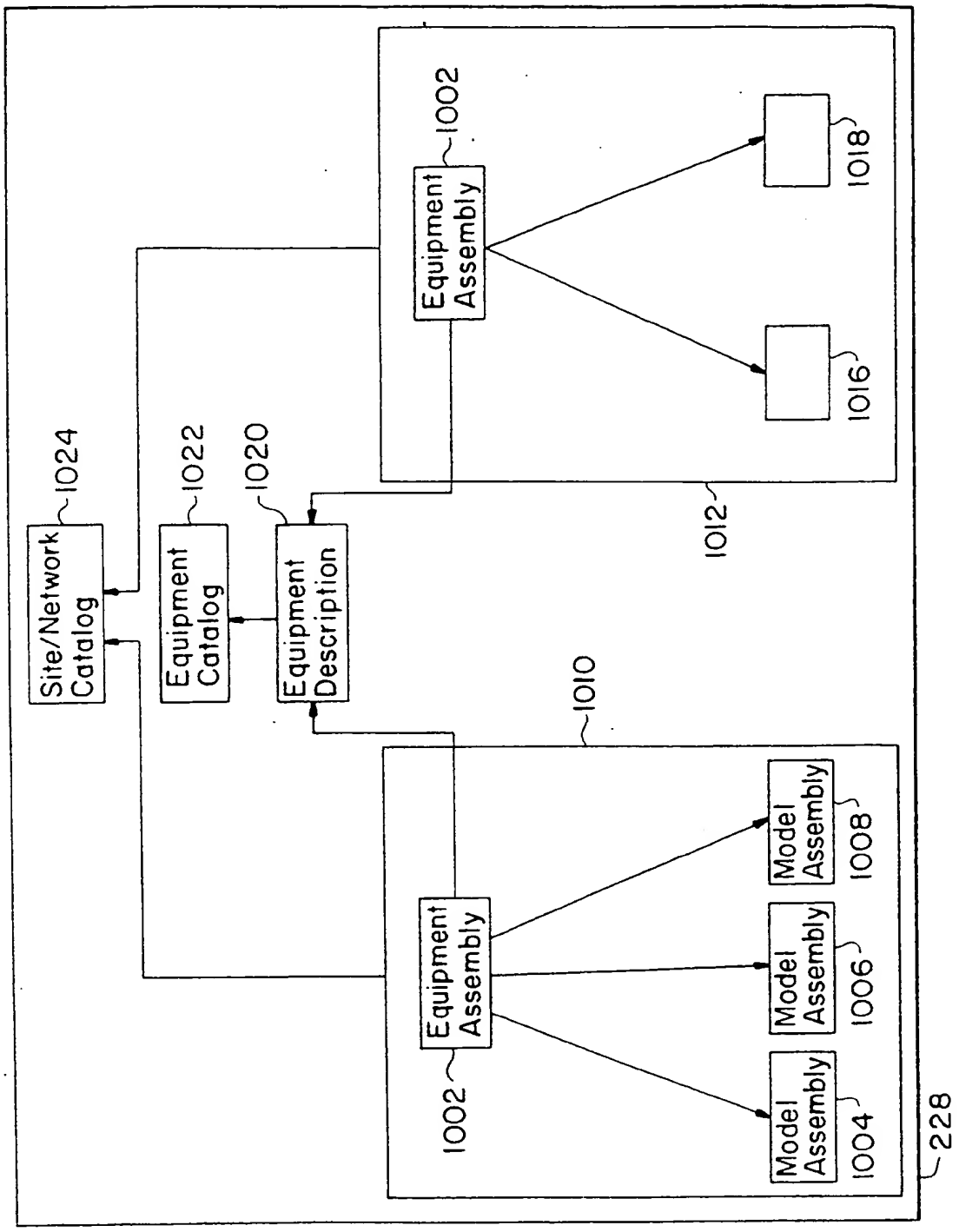
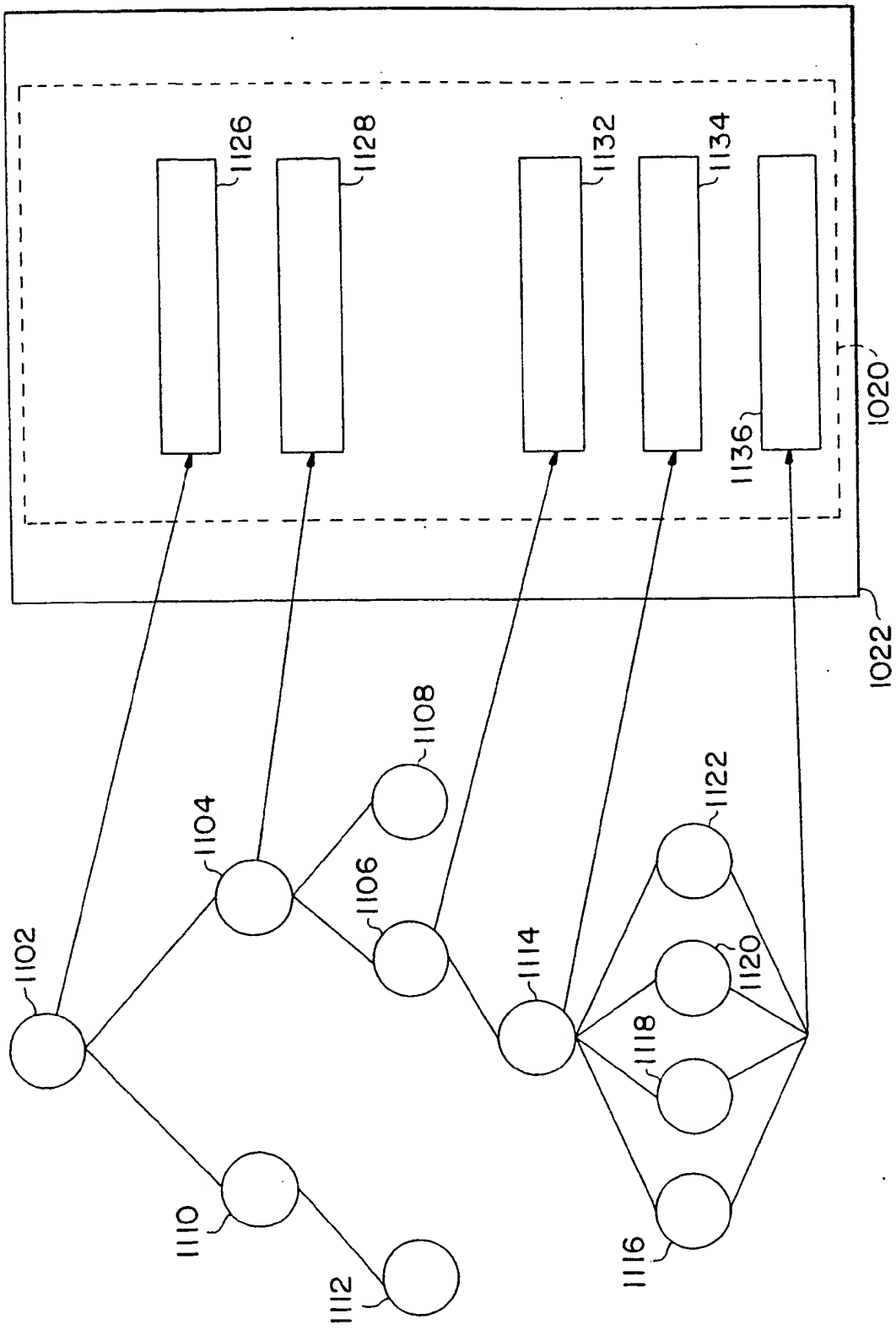

Site/Network Catalog
1024
Equipment Catalog
1022
Equipment Description
1020
Equipment Assembly
1002
1018
1016
1012
1010
Equipment Assembly
1002
Model Assembly
1004
Model Assembly
1006
Model Assembly
1008
228

FIG. 9

FIG. 10


1126
1128
1132
1134
1136
1020'
1022
1102
1104
1106
1108
1110
1112
1114
1116
1118
1120
1122

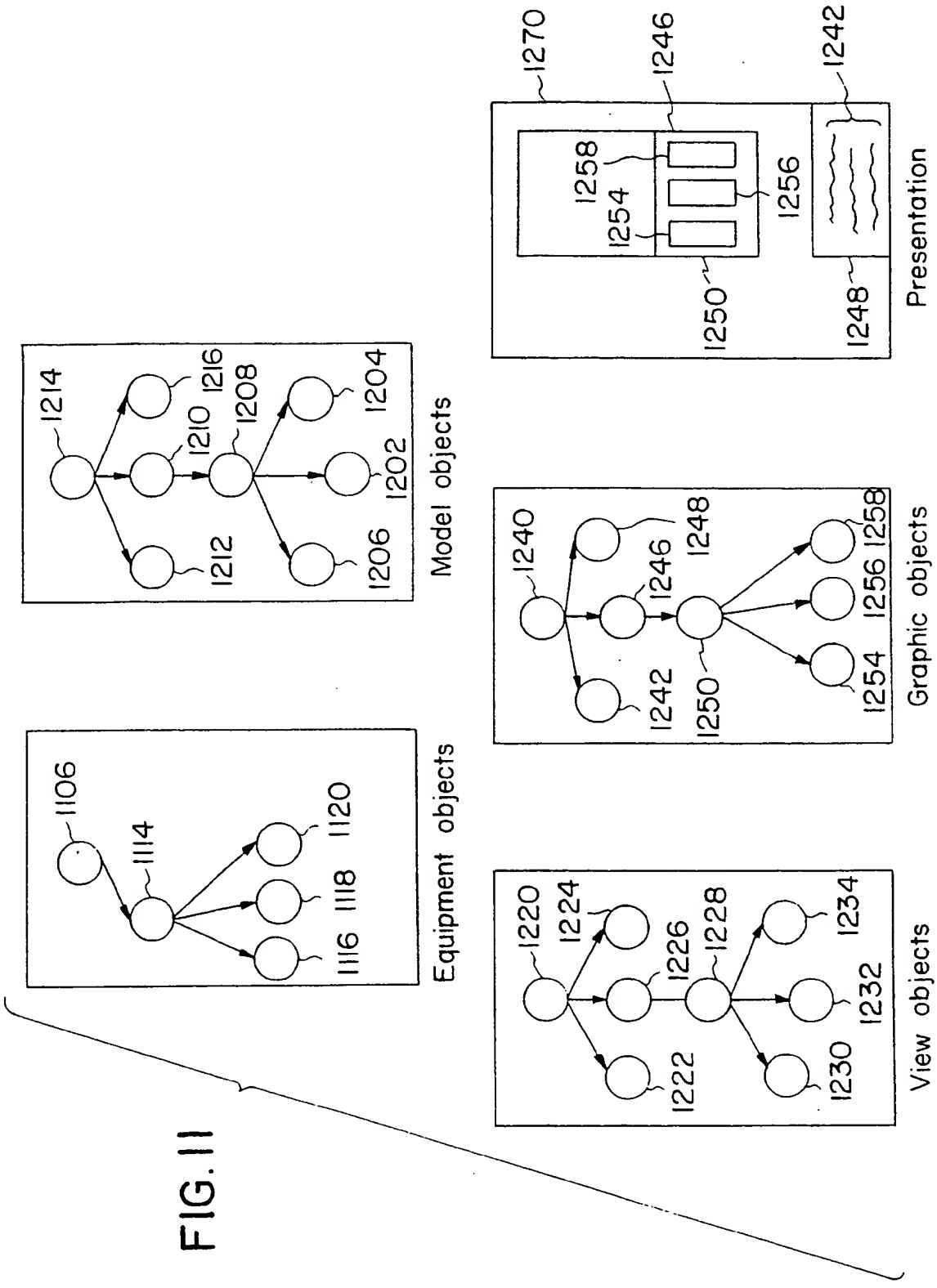

1106
1114
1116
1118
1120
Equipment objects
1214
1210
1216
1208
1204
1212
1202
1206
Model objects
1220
1224
1222
1226
1228
1234
1232
1230
View objects
1240
1246
1248
1242
1250
1254
1256
1258
Graphic objects
1270
1246
1242
1258
1254
1256
1250
1248
Presentation

FIG. 11

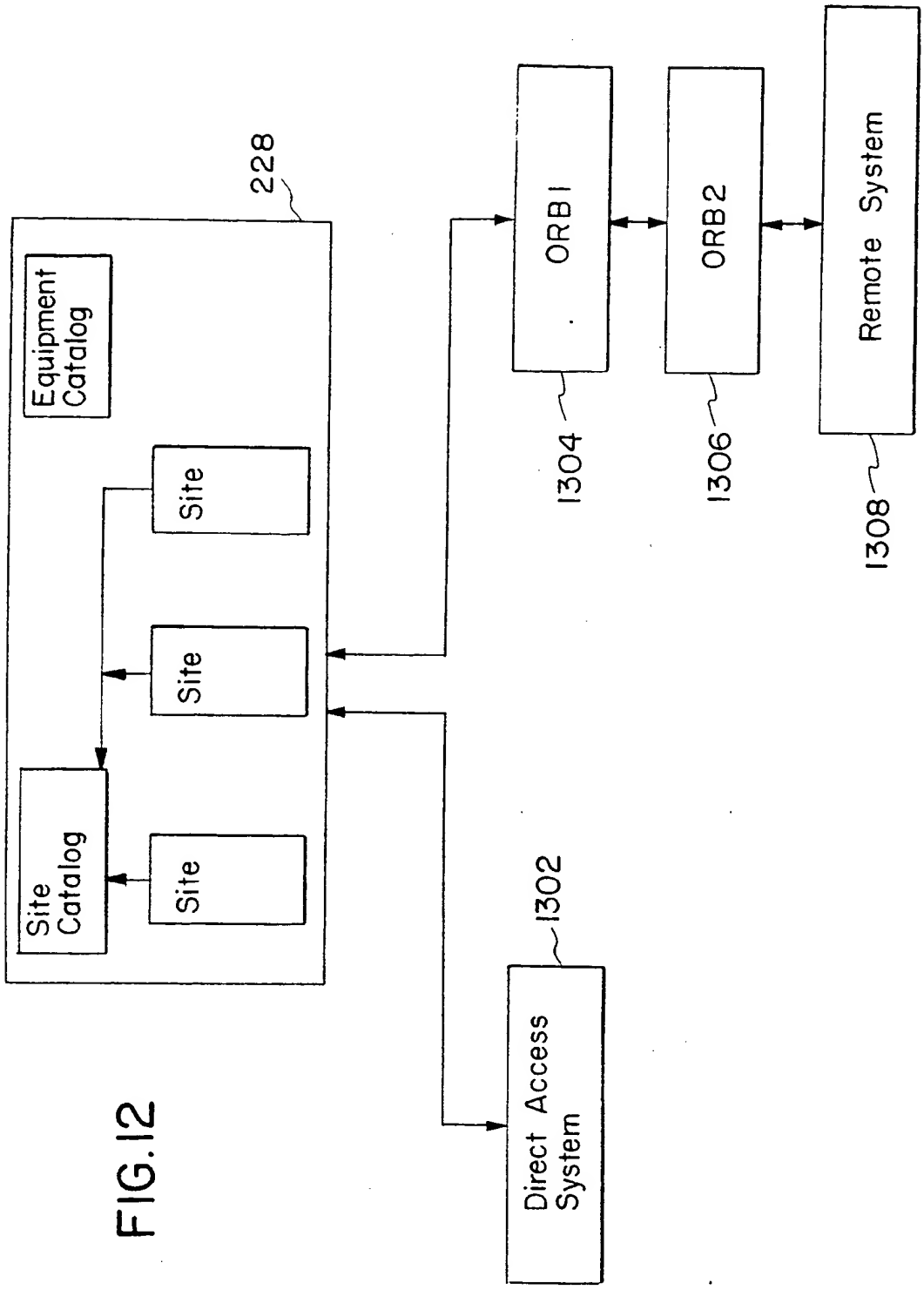

228
Equipment Catalog
Site
Site
Site
Site Catalog
ORB 1
ORB 2
Remote System
1304
1306
1308
1302
Direct Access System

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/00720

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G06F 17/50
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9301557 A1 (QUINTERO, STEPHEN ET AL), 21 January 1993 (21.01.93), see whole document	1-26
A	US 5050091 A (STEVEN M. RUBIN), 17 Sept 1991 (17.09.91), see whole document	1-26
A	US 4789944 A (YUTAKA WADA ET AL), 6 December 1988 (06.12.88), see whole document	1-26
A	GB 2255661 A (TECNOCAD LIMITED), 11 November 1992 (11.11.92), page 6, line 17 - page 8, line 5; page 9, line 12 - page 10, line 9; page 12, line 3 - page 13, line 21, figure 2	1-26

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 November 1995	06.11.95
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Jan Silfverling Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/00720

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ABB Review 6/91 page 35-38 Jürgen Bethmann A CAD/EDP package for planning and construction of HV substations see whole document --	1-26
A	Elteknik med aktuell elektronik 1985:10 page 46-48, Per-Arne Gussander Industrigrupp tar fram gemensamt cad-system see whole document -- --------	1-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/10/95

International application No.
PCT/SE 95/00720

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 9301557	21/01/93	AU-A- 2309792	11/02/93
		CA-A- 2112977	21/01/93
		EP-A,A- 0598748	01/06/94
		US-A- 5293479	08/03/94
US-A- 5050091	17/09/91	CA-A- 1270067	05/06/90
		EP-A,A,A 0196940	08/10/86
		JP-A- 62001071	07/01/87
US-A- 4789944	06/12/88	DE-D,T- 3650005	17/11/94
		EP-A,A,A 0195976	01/10/86
		JP-B- 6038266	18/05/94
		JP-A- 61213969	22/09/86
		KR-B- 9409382	07/10/94
GB-A- 2255661	11/11/92	NONE	

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